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SOME OBSERVATIONS ON DEMOGRAPHY IN SELECTED MACROECONOMETRIC MODELS OF CANADA

by

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January 1987

This study was commissioned by The Institute for Research on Public Policy in connection with Health and Welfare Canada's Review of Demography and its Implications for Economic and Social Policy (The Demographic Review). For a complete list of Institute discussion papers related to the Demographic Review, see inside back cover.

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91-01503/

Table of Contents

1. Introduction 1

2. A Historical Perspective 3

3. The Large Models of the Bank of Canada – RDX2 and RDXF 6

4. The CANDIDE Models 9

5. The Informetrica Model 11

   a. Background and General Model Description 11

   b. The Current Demographic Sector of TIM 12

   c. Demographic Links with the Simultaneous Core of TIM 15

   d. Prospective Demographic Sector of TIM 17

   e. Uses of the TIM Model, Past, Present, and Future 20

6. Some Recent Applications of the Models Measuring Macroeconomic Impacts of Immigration 21

7. Concluding Remarks and Recommendations 24

Footnotes 27

References 31

SOME OBSERVATIONS ON DEMOGRAPHY IN SELECTED MACROECONOMETRIC MODELS OF CANADA

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1. Introduction

Demographic factors play an important role in the evolution of a modern economy, and these factors are recognized in most current macroeconometric models. Thus, labour force draws from the relevant source population; residential construction is influenced by household formation as, in principle, each household requires (at least) one residence; and aggregate savings rates may reflect (among other factors) the average "dependency ratio" (the ratio of dependent-aged population to that assumed to be economically active). In addition, it has long been realized that social (government) spending reflects strong demographic influences: with the "baby boom" of the 1950s and early 1960s, spending swelled for new school construction and for teachers' salaries. A major concern at present is that, with the aging of the population, government expenditures will have to increase – perhaps dramatically – for medical expenditures (as senior citizens are heavy users of hospitals and other medical services) and for old age pensions. Other links are possible,[1] and some of these will be mentioned in connection with the individual macroeconometric models of Canada that we survey below. In this review paper, we shall put major stress only on the influence of demographic factors on the macroeconomic variables explained within each model. Moreover, when there appears an internal explanation (even a partial one) of some of the underlying demographic phenomena, it will be examined.

Of course, from the time of the English clergyman, T.R. Malthus, it has been recognized that the reverse causation can exist as well, with demographic factors influenced by economic variables. Thus, the Malthusian theory of population suggested that birth, death and marriage rates were very much influenced by the degree of prosperity among the working classes in his time. A decade ago, Canadian macroeconometric models tended not to explain the fundamental demographic determinants of the economy (with the possible exception of net immigration), being content to take fertility rates, survival rates, marriage rates and divorce rates as being exogenous to the economic system. Today, economists are not so sure, and two of the models that we have examined have extensive endogenous demographic content (CANDIDE 2.0 and TIM). In this survey we shall devote a considerable amount of time to summarizing the structure of these two general purpose models.

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Our plan, then, is as follows. After this introductory section, we examine four historic macroeconometric models of the Canadian economy, to see the uses that the respective model-builders have made of demographic phenomena. The models surveyed are one of the late T.M. Brown's sequence of models built under the auspices of the Government of Canada, the Caves-Holton model, Rudolf Rhomberg's unique model of the Canadian economy, and the TRACE Model built by the Institute for Policy Analysis of the University of Toronto. In Section 3 we examine the large models of the Canadian economy built at the Research Department of the Bank of Canada. The giant CANDIDE and TIM Models occupy our attention in the following two sections (Sections 4 and 5), where it seems readily apparent that one of these models should be currently employed, if realistic demographic simulations for some years into the future are required. The next section (Section 6) presents a summary of a number of studies dealing with a specific application of these macroeconometric models; namely, their use to attempt to gauge the medium-term impacts of varying levels of net immigration into the Canadian economy. These studies remain controversial, and so our concluding Section (Section 7) will attempt to assess the validity of the arguments of the two sides in this continuing debate. More generally, Section 7 attempts to place the models and their policy applications in some sort of perspective.

One question that will concern economic decision-makers is the potential accuracy of the macroeconometric models, when expanded sufficiently to contain a demographic submodule. We may ask ourselves whether the macroeconometric models are sufficiently accurate in their demographic sectors and feedback relationships that they may be employed in not only medium-term (5 to 12 years) projections, but also in long-term projections (say over 12 years). Cast in the terms of a unique and determined prediction, most long-term projections of the macroeconometric models (and not only those of the demographic variables) would become quite unreliable, if not outright useless. Fortunately, we may argue that such projections have a use when interpreted as scenarios or conditional projections. In one sense, the view that the future is not completely determined from present circumstances is an optimistic one, because it means that we are free to shape this future (within certain limits) according to our tastes. In the area of demographics, this might be interpreted as follows: the level and the composition of the population some 40 years into the future will be quite different, depending upon whether Canada follows a wide-open or a largely closed policy with regard to immigration. In this context, the macroeconometric models can provide some insights into the economic consequences of this policy decision, as they can of a number of other policy decisions as well. Of course, the longer one projects into the future, the greater the risk of a break in structure, which severely limits the applicability of these projections. Hence, these projections have to be used with a great deal of caution, and, in our view, long-term projections should be used simply as suggestive indications, to be combined with other evidence in forming a tentative judgment. A great virtue of a macroeconometric model is that the projections that it generates will at least be internally consistent, which, although a weak test, is a useful one.

2. A Historical Perspective

A Canadian debut of macroeconometric modelling was made at a fairly early stage when T.M. Brown put together the first model in the summer of 1947 at the Department of Reconstruction and Supply with Lawrence R. Klein retained as a consultant. Thereafter followed a phase of slow and steady development during the 1950s and most of the 1960s; however, the end of 1960s witnessed a rapid growth, which continued strongly into the decade of 1970s. The symposium (May 1979) issue of the *Canadian Journal of Economics* serves as an important landmark in the evolution of macroeconometric modelling in Canada. This trend has continued unabated into the 1980s, as the increasing use of these models is beginning to be made by the business forecasting firms. In this section, we make brief note of selected macroeconometric models which seem to have some demographic relevance from a historical perspective.[2]

The first model, constructed in the summer of 1947 with a view of assisting with the governmental forecasting and policy formulation, led to an ongoing project of continued revisions and model expansions. These early endeavours resulted in a series of subsequent models; for example, models associated with T.M. Brown (1964, 1970), Model XIV designed by his associate, Sydney J. May (1966), and finally John Kuiper's model (1970) at the Department of Finance. Model IX, the last model produced directly by Brown in the fall of 1959 and described in Chapter 17 of his book, *The Specification and uses of Econometric Models* (1970), may be taken as representative of this series for our purpose and so may be discussed briefly.

Model IX had eight sectors described by 49 equations, of which only 12 were behavioural equations, fitted to the split sample period of 1927-1941, 1946-1958 and estimated by the method of two stage least squares. It further distinguished three industrial groups: agriculture, non-agricultural business and the government.[3] The eight sectors were as follows: household sector, business sector, labour market, international sector, money market, government sector, global market for final goods and services, and a miscellaneous sector consisting of several identities and definitions. Some equations appeared commonly under two sectors.

The aggregate consumption function of the household sector incorporates a habit persistence effect and the breakdown of disposable income into labour income and property income. However, it does not include the population variable. The supply of labour emerging from the household sector, both in terms of participation rate and the number of hours, shows a backward sloping supply curve in real wage rates as well as being negatively related to wealth. The participation rate is defined in rather aggregative terms as the ratio of the total labour force to the total population 14 years of age and older; the denominator of this ratio is an exogenous variable. The business sector has six behavioural equations from which aggregate supply and demand for factors of production are estimated explicitly. The production function shows increasing returns to labour and capital; the demand for labour is a generalization of the income share equation, and the demand for standard hours is based on the employment rate. Gross fixed investment demand incorporates an accelerator component, and an inventory investment equation implicitly distinguishes unintended from desired or 'equilibrium' inventory changes. The import demand function has a standard but weak relative price

effect; however, its income effects are decomposed by category of aggregate demand such as inventory investment and machinery and equipment purchases. The import demand function also has a "trigger" variable, namely the deviation of the actual unemployment rate from three per cent when the unemployment rate drops below this critical value; thus imports are one of the safety valves of an overheated economy. In the labour market adjustment process, this trigger variable becomes instrumental in capturing non-linearity due to the downward stickiness of the wage rates. The demand for exports is exogenous and the treatment of the money market is standard and straightforward. The model was principally used for short-term forecasting, despite the fact that it contained a number of policy instruments, both monetary and fiscal.

The noteworthy demographic variables in this model appeared only through the labour force. The supply of labour was two-dimensional: by population and participation rate. The estimate of the civilian labour force was based not on total population but only on the population 14 years of age and above. A further adjustment was made by excluding employment in the armed forces and employment in the Canadian Yukon and Northwest Territories. More importantly, the participation rate was distinctly determined by economic factors. There was no explicit inclusion of immigration, fertility rates or any other demographic factors. Thus demographic phenomena were essentially exogenous to the model.

The first non-governmental model of the Canadian economy was a small model constructed by Richard E. Caves and Richard H. Holton (1959), which incorporated both immigration and emigration as well as the birth rate among the endogenous variables of the system. It was a long-term growth model fitted by ordinary least squares to five-year totals over the period 1901-1955. It had nine behavioural equations and three identities. The model recognized the openness of the Canadian economy to external influences through international trade as well as immigration and emigration, as already mentioned. Exports are explained by foreign income and imports by domestic demand, which is measured both by the level of domestic investment and export demand. Domestic economic opportunities measured by the level of business investment explain gross immigration as it deviates from a declining trend. Emigration is linked to the pull of employment opportunities abroad and the level of immigration of the preceding semi-decade. (This variable reflects the so-called Hurd-Lower thesis, according to which immigrants have a tendency to displace native Canadians.) The other five behavioural equations explain two categories of investment (residential construction and all other), national output, labour force and the birth rate. The birth rate is basically determined by output growth and a declining trend; the death rate is treated exogenously. The overall impact of demographic variables (birth rate, death rate, immigration and emigration) filters through population and labour force on the supply side, except for immigration, which also explains residential construction on the demand side.

Caves and Holton used this model simply to describe the long-term Canadian economic growth and to test various hypotheses. The model as a whole was found to be statistically weak and thus was not used for predicting Canadian economic growth.[4]

Perhaps the most celebrated early econometric model of the Canadian economy, which also focussed on its openness, was that constructed by Rudolf Rhomberg (1964). The

model described the operation of the Canadian economy under fixed and fluctuating exchange rates, and compared the efficiency of both monetary and fiscal policies under these two contrasting regimes. It was fitted to the quarterly data for 1952-1959 by the technique of limited information maximum likelihood estimation. It contained 17 behavioural equations and two identities. Among the behavioural equations were seven aggregate demand relationships, three price level equations, two technical linkages, and two equations explaining the short-term and long-term interest rates respectively. Rhomberg used this model for extensive calculations of both impact and dynamic multiplier. Since this model had no demographic variables whatsoever, its details are less relevant for our immediate purpose.[5]

The first medium-size model containing 44 behavioural equations and 139 identities (or 183 in all), with 126 exogenous variables, emerged from the work at the Institute for Policy Analysis of the University of Toronto. The TRACE (for *To*R*o*nto *A*nnual *C*anadian *E*conometric) Model dates from 1968 and it has gone through many versions; however, we refer here to Mark IIIR, a somewhat later version which appeared in Sawyer *et al.* (1976), and on which simulation experiments assuming alternatively fixed and flexible exchange rate regimes were conducted.[6] The model was estimated by ordinary least squares by using annual observations for 1947-1971 in general. It is a highly dynamic model and has a number of significant non-linearities. However, from an operational point of view, it has tended to be medium term in outlook with projections made for periods five to 10 years into the future.

As described by its authors, TRACE can be thought of as a statistical dynamic application of a Neo-Keynesian aggregate supply and demand apparatus to an open economy. It encompasses 14 model sectors: consumption expenditure on goods and services, government expenditure on goods and services, business gross fixed capital formation, foreign trade, gross national expenditure (income identities), production (and potential output), wages and price levels, employment and hours, factor incomes, taxes, government revenue and expenditure accounting identities, interest rates, capital formation and savings accounting identities, and international capital flows and exchange rates.

The production concept incorporated in the model is that of a Cobb-Douglas two factor (labour and capital) production function, and this underlies the estimation of potential output and investment functions, as well as the labour demand relationship. As a matter of fact, the role of demographic variables is simply introduced and captured through the labour force and the production function, except that the labour force and the participation rates are broken down into two categories: primary (males 25-54 years of age) and secondary (all other workers). Whereas the primary participation rate is treated as exogenous, the secondary rate is explained by the real wage rate, the employment rate and its own lagged value. Other demographic variables, such as immigration, birth rates and death rates, appear nowhere in the model. Thus, in spite of the fact that TRACE has had numerous applications, this model would have been ill-suited for our purpose of the estimation of the impact of fertility, immigration, age structure and other demographic factors on the aggregative economy.

3. The Large Models of the Bank of Canada – RDX2 and RDXF

We may now review demographic aspects of the two large models of the Bank of Canada, RDX2 and RDXF. Our discussion will focus mainly on RDX2, as it is our impression that RDXF is somewhat simpler, from a demographic point of view, than its predecessor. (For example, net immigration, the subject of an extensive treatment in RDX2, was simply taken as exogenous in RDXF.)

The model RDX2 (for *R*esearch *D*epartment e*X*perimental – Version 2)[7] in fact comes in two versions. The first version, built at the beginning of the 1970s and described in Helliwell *et al.* (1971), contained 258 equations (of which 141 were behavioural equations fitted, generally by ordinary least squares, to data usually beginning in the 1950s and generally terminating in the fourth quarter of 1968). The second version, which was the version for the second half of the 1970s and which was employed in the models symposium of the May 1979 issue of the *Canadian Journal of Economics*, was larger still, with 161 behavioural equations, 164 ordinary identities, and 191 tax structure equations (516 equations in total). (See Bank of Canada, 1976a and 1976b; as the title of the first reference indicates, the sample period was updated to end in the fourth quarter of 1972, which was useful to capture some contemporary experience with a floating rate of foreign exchange. The method of parameter estimation remained principally ordinary least squares.) The RDX2 Model generally described the Canadian economy as being nearly continuously in a state of disequilibrium, although the economy was also viewed as moving toward equilibrium in the absence of further (stochastic or systematic) disturbance. Thus, for instance, a strong distinction was made between intended inventory investment (reflecting the traditional sales accelerator) and unintended inventory investment, which acts as a buffer to sudden changes in aggregate demand. Also, the production function for business output (other than construction) showed considerable variations in short-run productivity levels, as factor inputs were estimated to adjust only with a lag to normal levels of output.[8] A centre-piece of the model was the submodel of the financial sector, as one might expect from an econometric model built in the Research Department of a central bank. (This had been the case with RDX2's predecessor, RDX1, also.) This financial sector was constructed around a model of portfolio adjustment of major financial institutions (the so-called Yale approach to financial theory), which reflects the public's changing preferences (due to changing wealth, interest rates and other determinants) for the various financial holdings possible. Short-term interest rates were determined in RDX2 by a reaction function of the monetary authorities, while long-term rates reflected term structure relationships and the influence of U.S. rates. Finally, in a floating rate regime, the spot rate is viewed as the Canadian dollar price of one U.S. dollar which will equilibrate the balance on current account with that of "normal" capital flows (long-term capital flows and any non-speculative short-term flows); in other words, it is a market-clearing price once all speculative capital flows would have stabilized. From the above description, we note the RDX2 continued the tradition of the Rhomberg model in depicting the Canadian economy as quite sensitive to foreign (particularly U.S.) influences.

Turning to the demographic sector of RDX2, we note that, although total births and deaths are exogenous in RDX2, there are equations for both (gross) immigration and emigration, and so total population is endogenous. Immigration (expressed as a

proportion of total population) depends on distributed lags in the unemployment rate, the real wage in Canada relative to real wages in sending countries, and the size of the Canadian population. (The first and third variables have negative and significant influences; the real wage ratio variable has positive but insignificant regression coefficients.) Emigration (again as a proportion of total population) depends positively on Canadian unemployment rates and negatively on U.S. unemployment rates (both in the form of reciprocals in a distributed lag formulation). The fit for this equation is not very tight, suggesting that many other factors influence emigration (or that the data are quite imperfect). The size of the population 14 years of age and older (the base of the labour force participation rate) is obtained by applying an exogenous proportion to the total Canadian population as a base. There is one labour force participation rate regression that is fascinating and for which the fit is quite tight. The proportion of those 14 years of age and older in the labour force is explained negatively by the proportion of this group enrolled in formal education (the numerator of this ratio is exogenous) and positively by a four-quarter average of real per capita disposable income, which might reflect either the cyclical tendency of the labour force to expand with employment opportunities, positive real wage responsiveness of the labour supply, or long-term trends. The most interesting variable is a long distributed lag (19 quarters) with equal weights in net immigration as a proportion of total Canadian population 14 years of age and older, which had a positive, statistically significant (by standard tests) influence and which helps to explain some interesting simulations that we summarize in the paragraph following the next one.

As noted in the introductory section, demographic phenomena have a pervasive influence in the RDX2 Model. Thus the consumption relationships are expressed on a per capita basis (for the population 14 years of age and older), while the key relationships in the demand for residential construction are expressed on a per family basis.[9] (We note that residential construction is quite sensitive to financial factors in general and to mortgage approvals (generated by the financial sector) in particular. In the foreign trade sector, most import and export equations (for those categories of exports that are endogenous) are not population-based, but the travel payments to the United States and those to other countries (both import flows) are estimated on a per capita basis (again for the population 14 years of age and older). As well, travel receipts from the U.S.A., an export category, are estimated with the key variables scaled on the basis of total U.S. population. Demographic influences also appear in government finance equations; namely, the explanation of hospital and medical care insurance premiums and in the submodel of unemployment insurance premiums and benefits. Finally, demographic influences appear in the two model sectors for government expenditures on goods and services, one for the federal government and one for the provinces and municipalities. Thus federal employment in public administration and defence as a proportion of the total population respond positively to real personal income and to the rate of unemployment (presumably reflecting conscious counter-cyclical policy) and respond negatively to relative government wage rates and to total population, presumably reflecting economies of scale. (Federal investment in non-residential construction is also demographically based, with the variables expressed this time as a proportion of total population 14 years of age and older. Here also, we have some evidence of conscious counter-cyclical policy and also of population economies of scale.) For the provincial-municipal spending equations, we note that employment in elementary and secondary schools under municipal control and school construction expenditures are both sensitive to demographic

influences. The former variable is expressed as a proportion of the total student population, although total population plays a role in terms of the influence of real personal income per capita. School construction expenditures are determined by a long distributed lag going back 11 quarters, in the total student population, which does not seem unreasonable.

One of the uses of RDX2 (which has also been used for a large number of policy simulations during its long life) may be indicated briefly here. The ordinary multiplier calculations of de Bever *et al.* (1978), as summarized in their contribution to the symposium on the simulation of models (de Bever and Maxwell 1979), displayed the now familiar shape of an inverted "U" for the dynamic multipliers, with the impact multipliers beginning at a low value (which was 1.0 in the case of RDX2), climbing slightly (to a peak of approximately 1.4 after three years for RDX2), and then trailing off toward zero (the RDX2 real multiplier was 0.5 after 10 years). This pattern, which also characterized the other Canadian models in the symposium, was substantially modified if the exchange rate and immigration links were allowed to influence the calculated multipliers. If only the exchange rate links are made operational, the inverted "U" shape for the RDX2 dynamic multipliers disappears, and, instead, the influence of a sustained increase in government expenditures appears to be cyclic, with a secondary peak in the values of the dynamic multiplier appearing some 12 to 13 years after the initial impetus. (The dynamic multipliers are virtually the same, according to RDX2, for the first 8 or 9 years.) When international migration is allowed to play a role, the changes are even more dramatic. The cyclical decline in the dynamic multiplier is not nearly so pronounced, and the secondary peak (again some 12 or 13 years after the initial impetus) is even higher (at a value of 2.0) than the primary peak which still occurs at a value of 1.4 after three years. One interpretation of these final results could be that the full RDX2 model is dynamically unstable, but de Bever and Maxwell argue (convincingly, in our view) that the sustained increase in government expenditures becomes a source of additional growth in this context, as the higher domestic demand draws in additional immigrants (and retards emigration), thus swelling the labour force (as we have seen). In any case, the critical role that international migration plays in this context should be highlighted. Finally, we may note that Gordon F. Davies' (1977) study of the economic impacts of variation in net immigration, which employed the RDX2, TRACE and CANDIDE Models, is summarized in Section 6 below.

We may now briefly describe the successor to RDX2, a model called RDXF. Here the emphasis has been on the development of a model with forecasting capabilities (and hence the "F" in the model mnemonic). By contrast, while RDX2 contained more elegant underlying macroeconomic theory, some of the variables that resulted from these specifications were highly intricate, and would become available only several quarters after the current period. Thus, in constructing RDXF, the model-builders were aware that they were trading ease of forecasting capacity for theoretical elegance; nevertheless, RDXF is broadly similar to its predecessor. RDXF (the version of December 1980) has 403 equations, of which 208 are behavioural equations, generally estimated by ordinary least squares over the 1961-1978 period. RDXF also has less emphasis on supply conditions than its predecessor, as the focus was principally on short-term forecasts over a two year horizon.[10] In particular, the demographic sector is not as well developed. Net immigration is taken as exogenous, and the labour force equation in the December 1980

version is quite simple: the aggregative participation rate is a positive function of a time trend (reflecting increased female participation at prime ages outweighing later school-leaving ages and possibly earlier retirements) and also a positive function of a cyclical variable (the employment-population ratio).[11] On the other hand, RDXF does have a number of demographic influences on the basic economy, which are similar to those found in RDX2. However, this is of lesser interest in this survey.

4. The CANDIDE Models

The CANDIDE (for *Can*adian *D*isaggregated *I*nter-*D*epartmental *E*conometric) system of models included Models 1.0, 1.1, 1.2, 2.0 and 3.0, along with several variants of some of these. The project began in 1970, originally as an inter-departmental effort of the Government of Canada (as the acronym implies). However, in recent years the Economic Council of Canada has taken increasing responsibility for the management and use of the CANDIDE Model; the Model has been used each year, for instance, in the medium-term projections incorporated in the Council's *Annual Reviews*. Although all the CANDIDE Models are quite similar, this review will focus explicitly on Model 2.0, as that is the most recent model for which readily available documentation (Preston *et al.* 1979; Grady Associates 1985) exists.

CANDIDE 2.0 contained approximately 2,400 equations in total, of which 783 were behavioural equations estimated by ordinary least squares from annual data running generally from the early 1950s to 1975. The Model also made use of 948 exogenous variables, including a fair number of policy instruments. A distinctive feature of the CANDIDE Model (all its variants) has been an extensive industry disaggregation; in Model 2.0, there were some 48 input-output industries modelled across a balanced disaggregation (investment, capital stock, employment, real domestic product, wages and industry price formation) of the economy. This effort involved the use of two input-output submodels, one for industry output determination and one for price formation of the implicit deflators of some of the categories of final demand expenditures. Accordingly, CANDIDE could be interpreted as a collection of industry submodels, supplemented by equations for the household, government, and foreign (non-resident) sectors. It is interesting to note that Model 2.0 could be described as somewhat more Monetarist and, hence, less Keynesian than its predecessors, as Model 2.0 incorporated an inflationary expectations mechanism (which appeared in the wage rate and interest rate equations, for instance), which reflected past rates of growth of the stock of money, among other determinants. Model 2.0 also contained an equation for determining the rate of exchange (under a flexible rate regime) on the basis of expected relative inflation rates, interest rate differentials, and short-term capital flows.[12] The CANDIDE Model has been viewed as a model for medium-term projections, five to 12 years into the future, with short-term cyclical phenomena of less importance;[13] at the other end of the projection period, it is hoped that 12 years into the future is not so long a period that structural change would vitiate completely the projections obtained.

Turning to the demographic sector of the CANDIDE system, we note that this sector was essentially exogenous in Model 1.0, although a large population submodel or population calculator was built to keep track of the interrelationships. However, the

fundamental determinants (birth rates, death rates, immigration flows, marriage and divorce rates) were exogenous, which implied that population was fundamentally a given set of values, for both the sample and projection periods. In Model 1.1, there was an equation for net immigration, in which the absolute values of this flow were related inversely to the lagged rate of unemployment of the Canadian economy, together with dummies to mark increased net immigration due to the Hungarian and Suez crises (in 1956-1957) and also due to the attractions of Expo 67. We note that, in CANDIDE, as contrasted with the treatment in RDX2, a treatment of immigration and emigration separately was not effected, so that high unemployment rates in Canada represent simultaneously both a strong "push" factor tending to propel emigrants out of Canada and also a feeble "pull" factor, reflecting unattractive labour markets domestically. The equation for net immigration in Model 2.0 is much more sophisticated, as it contains explicitly both "push" and "pull" factors: net immigration depends positively on the Canadian real wage rate and also (with a lag) on the U.S. rate of unemployment; it depends negatively on the U.S. real wage rate and also (with a distributed lag) on the Canadian rate of unemployent. As with the Model 1.1 equation, the fit is rather tight and all of the individual variables are statistically significant.[14] Model 2.0 also has equations for fertility rates for females 15 through 24 and for females 25 through 44,[15] as well as a "births adjusting entry" to take account of fertility outside of these prime birth age groups. There were also six equations for various types of school enrolments (full-time and part-time undergraduate, full-time and part-time graduate, non-university post-secondary, and elementary and secondary school enrolments), a marriage rate equation,[16] an equation for the ratio of the deaths of married persons to total families in the preceding period, and an equation for the ratio of non-family households to total population 14 years of age and older. The outputs of this demographic subsector were (as in all versions of the CANDIDE Model) total population, population by age-sex cohort, the total number of households and its break-down into family and non-family households; in addition, in Model 2.0, various school enrolment magnitudes were determined. Finally, we may note that the divorce rate was an exogenous variable, and that there were adjustment equations to correct for the first predictions from a crude cohort model, analogously to what was done for industry output determination on the basis of the I/O submodel of industry output determination. Although we have not seen the details, it is our understanding (based on the-interview with Ross S. Preston, October 10, 1986) that the demographic sector of Model 3.0 is quite similar to that of 2.0.

Turning to the influence of demographic variables in the CANDIDE system of models, we note that in Model 2.0 there are participation rate equations for four male age groups (14-19, 20-24, 25-54 and 55 and over) and for three female age groups (14-24, 25-44, and 45 and over). The participation rate equations display discouraged worker effects for young females and for young males and also for females over 45; by contrast, prime age females (25-44) and older males (55 and over) display additional worker effects. An Unemployment Insurance dummy suggests increased participation rates for some age-sex groups, subsequent to the 1971 revisions of the unemployment insurance system; in addition, increased real pension benefits have had a significant effect in reducing participation rates of older males. Direct demographic effects in the participation rate equations themselves include the tendency for child-bearing to be a substitute for labour force activity for women of child-bearing ages and for post-secondary enrolment rates to reduce labour force participation of young people. There are also important demographic

effects on a number of categories of aggregate demand. In Model 1.1, a high child dependency ratio[17] decreased the amount of personal discretionary savings. Although this effect is gone in Model 2.0, a modified demographic influence may be found in the new equation for personal discretionary savings, in which real personal discretionary savings vary directly (at given values of real disposable income) with the change in the unemployment rate, which itself is entered multiplicatively with the level of current real disposable income. Demographic phenomena enter extensively the final demand sector, particularly for the consumption category relationships (which are formulated in per capita terms), for the submodel of residential construction (where household formation is an important part of the explanation), and for government expenditures on various categories of goods and services. On the incomes side, various tax-transfer models depend on demographic phenomena; old-age pension payments and family allowances are obvious examples. In concluding this summary, we may note that, because the demographic subsector contains a number of current macroeconomic variables as right-hand side (explanatory) variables, it cannot be solved recursively. Rather, in CANDIDE Model 2.0, the full macroeconomic-demographic system had to be solved simultaneously. This was a large departure from previous versions of the CANDIDE Model, where the values of the demographic variables could be obtained *before* the macroeconomic system proper was entered.

The uses of the CANDIDE Models have been many and varied; only a few can be indicated here. Versions of the CANDIDE Model have been used for multiplier studies (e.g. Waslander 1979); for a study of the short-term trade-off curve for the Canadian economy (Bodkin, Chabot-Plante, and Sheikh 1975); for projections of occupational requirements on the basis of an additional module constructed in the former Department of Manpower and Immigration (now Employment and Immigration); and a specific study of the effects of the 1971 reforms of the system of unemployment insurance on the Canadian economy in general and on the measured rate of unemployment in particular (Siedule, Skoulas, and Newton 1976). Perhaps the most interesting studies, from the perspective of the present review, were those which tried to measure the impact of varying levels of net immigration on the Canadian economy. The two studies of interest here are Davies (1977) and Rao and Kapsalis (1982); these studies used Models 1.2 and 2.0, respectively. They will be reviewed briefly in Section 6 below.

5. The Informetrica Model

a. Background and General Model Description

TIM (*T*he *I*nformetrica *M*odel) is a lineal descendent of the CANDIDE Model, as is recognized in the pertinent Informetrica documentation (1982). When Informetrica introduced its National Forecast Service, the need for a separate, proprietary model was felt, and TIM parted ways with the then current version of the CANDIDE Model. The first version of TIM was released in 1979. TIM is large, possibly the largest macroeconometric model in the world. According to our count, the January 1986 version of TIM has 963 behavioural equations, 2,423 ordinary identities, and 755 input-output relationships, for a total of 4,141 model equations; there are also 1,066 exogenous variables (including those variables said to be "exogenized" in the model code).[18] The behavioural equations are

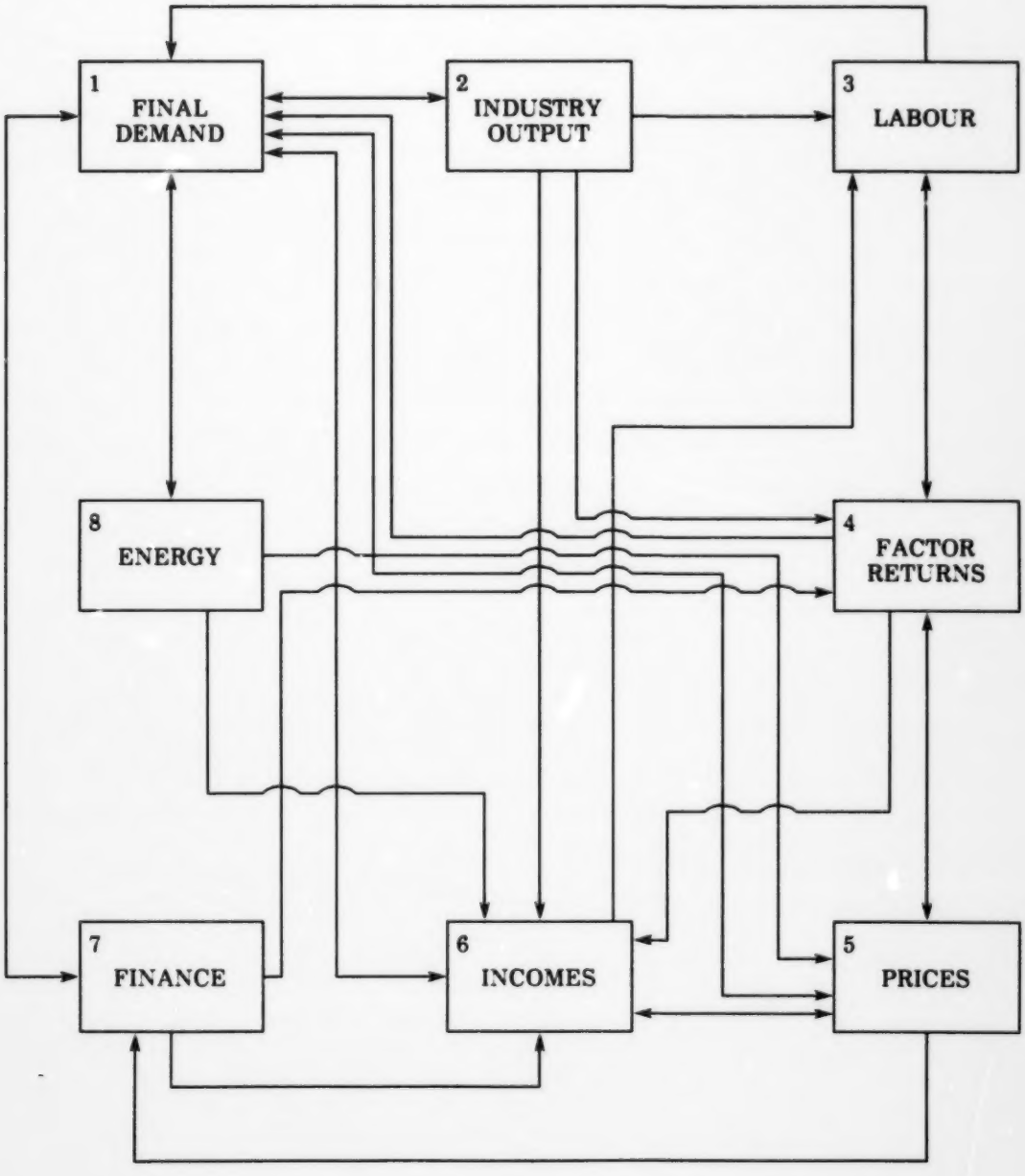
generally fitted to annual data beginning in the late 1950s or early 1960s and running to 1984. To return to the size of TIM, we note that it is still growing larger; thus the version of early 1982 had only roughly 2,600 equations, while the current version (Fall, 1986) has approximately 4,400 equations. This has been done because the directors of Informetrica Limited believe strongly in the advantages of detailed disaggregation, at least with the availability of modern computing facilities. In addition, the large size of TIM reflects the desire to construct a macroeconometric model that could be useful in the construction of satellite or peripheral models to produce estimates of industrial detail, occupational disaggregation or some other phenomenon of interest. (This sort of modification can be particularly useful in consulting work.) Thus TIM, like the CANDIDE Model, is designed to be a general purpose model, useful in a variety of applications.

The general structure of TIM may be quickly demonstrated by a flow diagram (reproduced with permission) from Informetrica (1982). This chart may be compared with a similar diagram from Bodkin and Tanny (1975). In making these comparisons, it becomes clear that the major structural design has not changed much between CANDIDE Model 1.1 and TIM, although the theoretical underpinning has continued to evolve and although more disaggregation and other detail has continued to be added, as indicated by the increasing size of the model.[19] One important modification (which is indicated implicitly by the differences in the two flow charts) is that TIM develops explicit equations for the return to capital and to other property income, which are then incorporated into industry price formation. Of course, as is evident from the charts, TIM retains the use of the two input-output submodels, one for use in industry output determination and the other to help explain the formation of implicit deflators of a number of categories of final demand. The exchange rate is mid-way between an endogenous and an exogenous variable; in particular, it is determined by a simulation rule (for projections) that relates changes in the exchange rate, under a floating rate regime, to changes in the real balance of the current account; however, the key coefficient in this relationship is a policy reaction parameter which can be modified from one simulation to another. With the rise of OPEC, an important modification to make was the development of an energy submodel. This submodel develops both the income and tax flows associated with energy production; these are calculated largely on the basis of institutionally determined energy pricing rules and rules for royalty payments, and the energy submodel requires exogenous assumptions about the world oil price and the levels of Canadian production. With the energy submodel, TIM produces a balance among output, exports, and internal demand within the model. Moreover, the correct disposition and impact of economic rents and tax flows is effected. As well, we obtain a consistency between the administered prices of the oil and gas sector and the associated factor incomes. We note from Figure 1 that the principal impacts that the energy submodel variables have are on variables relating to sectoral incomes and also to domestic price formation; there are, however, feedback relationships with the final demand sectors.

b. The Current Demographic Sector of TIM

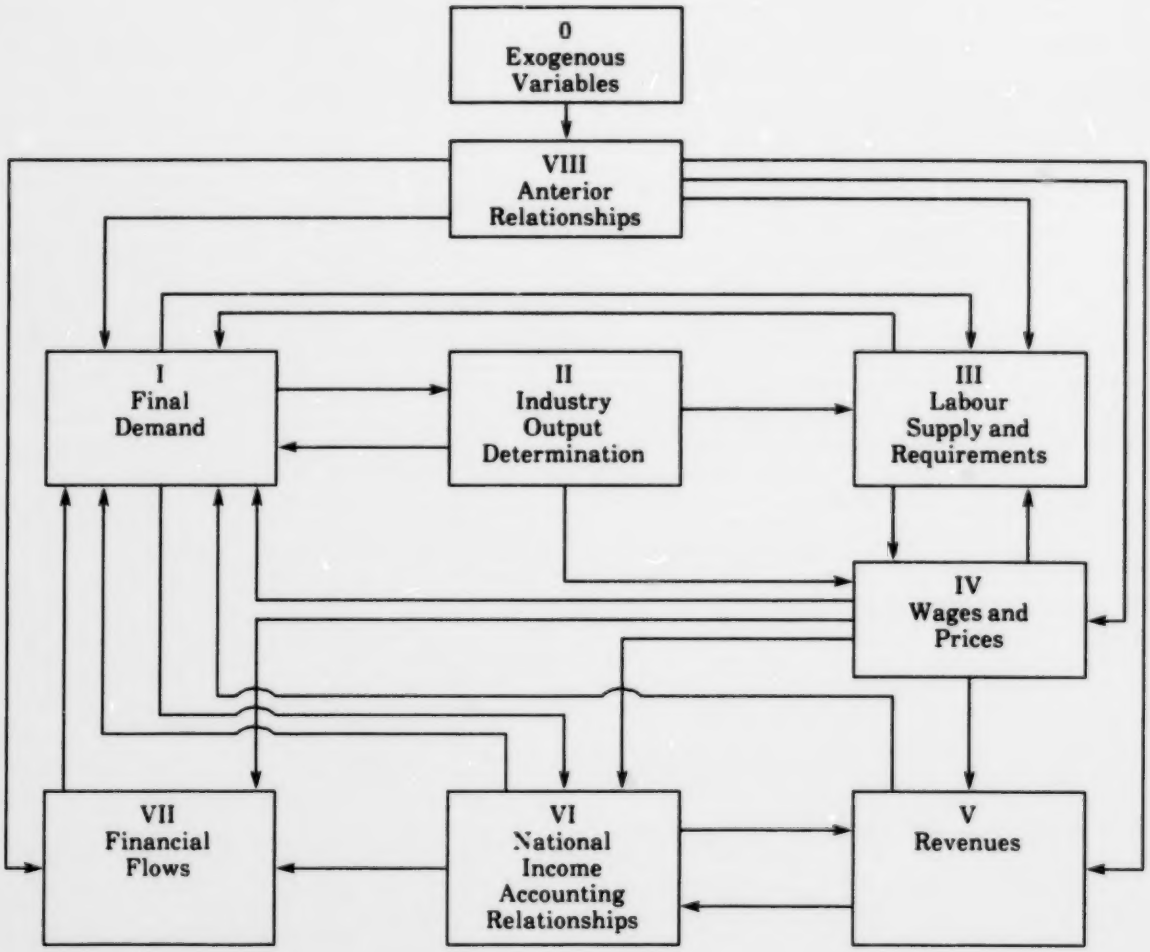
At present, the basic demographic sector of TIM is very simple. Like the demographic sector of CANDIDE Model 1.0, the demographic sector of TIM is essentially a population calculator which can be solved before any of the strictly economic variables

FIGURE 1
TIM FLOW CHART
THE INFORMETRICA MODEL – SECTORAL STRUCTURE



Source: Informetrica (1982), p. 0.5.

FIGURE 2
SIMPLIFIED FLOW DIAGRAM OF MAJOR LINKAGES, AMONG THE SUPERSECTORS OF CANDIDE MODEL II



Source: Bodkin and Tanny (1975), p. 35.

of the system are obtained from a solution of the large simultaneous core of the model. In this regard, it contrasts markedly with CANDIDE Models 2.0 and 3.0, as we have seen. The fundamental determinants of the population calculator are fertility rates, survival rates, non-family formation, marriage and divorce rates, and immigration and its components. Given these fundamental determinants, the population calculator then generates the total population, the total number of families and non-family households, and the sizes of various population cohorts. These cohorts are five-year age groups, separately for each sex, up to age 70; the most senior cohorts are aged 70 and over. In addition, the model keeps track of the births, so that we have two cohorts aged less than one year of age. Moreover, exogenous enrolment rates are applied to the appropriate cohorts to obtain total educational enrolments of various types. (The most complete accounting is that for university education, which is disaggregated by sex, by full- or part-time attendance, and by undergraduate or graduate programs.) We note that the population variables are thus essentially given values during the sample period, whether for purposes of estimation or for within-sample-period simulations. However, when making projections into the medium-term future, TIM's population calculator allows a consistent projection of the underlying demographic determinants of the economic system.

We may also note that TIM abandoned the endogenous mechanism for explaining net immigration, developed in Model 1.1 and succeeding versions of CANDIDE. This was done with the view that immigration is critically a policy variable, so that it makes little sense to project it on the basis of a regression based on past sample data, when a change in policy regime is almost certain to produce a critical break in structure. (Of course, an endogenous relationship, whose constant term could be adjusted, could have been used, also.) As one might expect, demographic effects on the central macroeconomy are very important in TIM, and this is the subject of our next subsection.

c. *Demographic Links with the Simultaneous Core of TIM*

With the demographic block providing the source population magnitudes, TIM estimates the cohort labour force by applying participation rates to these source population levels for 12 age-sex groups: males, 15-19, 20-24, 25-54, 55-64, and 65 and over; and females, 15-19, 20-24, 25-34, 35-44, 45-54, 55-64, and 65 and over. (We note that the total source population excludes members of the armed forces and residents of an institution.) The total labour force is the sum of the economically active population for each age-sex group. We note also that the participation rate for prime-age males (25 through 54 years of age) is exogenous. Up to five years ago, this rate was always very close to 96 per cent; then, in the 1981-1982 recession, it dropped to 92 per cent. Recently , it has recovered to 94 per cent, and it will be interesting to see whether this participation rate stabilizes at this new level or returns to the earlier level. In any case, it may be fruitful to attempt an endogenous explanation of this particular participation rate, in the future.

For the other 11 groups, participation rates are endogenous and are obtained from a fitted regression. For the younger groups, school enrolment rates have the expected negative effects on labour force participation. Another important explanatory variable is total unemployment insurance benefits plus total compensation per worker in real terms,

which is found to have a positive effect on participation in most categories. (This is similar to the effects in CANDIDE 2.0, except that it recognizes that unemployment insurance benefits are also a positive inducement to labour force participation. As before, the problem of confounding the effect of the variation in the economic variable and that of a time trend remains.) The impact of the rate of unemployment itself varies from group to group; for most groups, discouraged worker effects are the rule, but for older women there is a tendency for an additional worker effect to appear. For workers of retirement age, pension benefits act as a negative inducement to engage in labour force activity. After the total level of the labour force is obtained, a comparison with total employment (generated by industrial output elsewhere in the model) yields an estimate of the unemployment rate, which is thus at least indirectly the result of demographic factors.[20]

Other demographic effects are numerous but small and thus can be indicated only briefly.[21] In the consumption-saving sector, the amount of real contractual savings is determined on a per employee basis, and two of the explanatory variables are expressed in these terms. The individual category relationships are generally expressed on a per capita basis, although in some cases the formulation is on a per household basis. In addition, other demographic factors may, on occasion, enter as explanatory variables, for the consumption category relationships. An important innovation of TIM is to distinguish between discretionary and non-discretionary income, which gives a sharper definition to the consumption demands for necessary consumption categories and others.

Another area where demographic phenomena are important is housing (residential construction). In TIM, it is basically assumed that all families would like to live in single-family dwellings, although economic necessity may force them into multiples. On the other hand, many non-family households would prefer to live in multiple units. This theory is translated into the submodel of residential construction, and so the relevant demographic variable for explaining single-family housing starts is the number of family households. Of course, financial factors and real incomes also play a role in explaining housing activity. It is also interesting to note that the housing submodel helps to explain some consumption categories, such as the electricity consumption of the domestic sector. (In addition, there are some direct links of demographic phenomena to the energy sector, particularly on the demand side.)

It is, however, in the government sector (expenditures, transfers, and receipts) that the most pronounced demographic effects may be observed. On the side of expenditures, we note that TIM defines a health-weighted index of the total population, which is based on the relative expenditures of the different age groups in 1975 and which thus represents the relative demands placed on the health care system; this index is used as an explanatory variable in the consumption and government sectors of the model, particularly the latter. Other government expenditures on goods and services also reflect demographic phenomena heavily; thus, university expenditures reflect enrolments of the various types, and school construction expenditures reflect the numbers of school-age children. There are, in addition, other demographic phenomena in the government expenditures sector, which in general is based on the view that there is much less autonomy for legislators to act than they or others might naively believe. On the side of transfer payments, demographic phenomena enter importantly at both ends of the life cycle. Thus, the numbers of children and youths have important effects on the payment of

one of these transfers from governments to persons, family allowances, while the numbers of persons 65 years of age and older have important effects on the payment of old age security benefits and Canada/Quebec Pension Plan payments. Although it is true that demographic factors do not directly explain unemployment insurance benefits, one might argue that demographic influences are present indirectly, as we have argued above. On the side of tax receipts, there are important demographic effects on income tax receipts (provincial and federal), as well as for payments into the unemployment insurance fund and the premiums for the Canada/Quebec Pension Plan. Another demographic influence appears in the submodel for EPF (Establishing Programs Financing), which is duly modelled in TIM.

Hence, while this rapid survey has no doubt failed to present all of the demographic effects on the main economic mechanisms in TIM, probably enough has been said to indicate the importance of demographic influences. Whether enough has been done within the model is, of course, a deep and fundamental issue. Immigration plays a role only through its effects on total population and on the relevant subgroups, a limitation that some might find unduly restrictive. We return to these questions in Section 7 below.

d. Prospective Demographic Sector of TIM

At present, the demographic sector of TIM may be undergoing dramatic changes, due to some interesting experimental work by D. Juliet Howland (1986). This work has not yet been incorporated into the basic TIM Model, but it may well be, at some future date, provided that the new demographic sector passes certain tests, both with regard to the sector itself and also with regard to its effects on the functioning of the full model.[22] With this by way of introduction, let us turn to a brief description of this work.

Basing her regression analysis on the work of Becker, Easterlin, Wachter, Ahlburg, and others (which is on the frontier between economics and demography), Howland has formulated relationships for the divorce rate, for fertility rates for four cohorts of women (ages 15-19, 20-24, 25-34, and 35-44), marriage-rate equations (for seven age cohorts), and two female university enrolment rates (one for graduate and one for undergraduate studies). Her paper also contains a reformulation of the participation-rate equations for all but males aged 25 through 54 years; Howland splits the 65 and over group into four groups: males, 65-69 and 70 and over; and females, 65-69, and 70 and over. Her paper concludes with some tentative projections to the year 2005. The actual figures obtained are of lesser interest to us than the underlying technique, which thus points the way to some possible directions of study.

Turning to the divorce rate equation, Howland finds a non-linear effect of relative income (defined as the ratio of current to expected income), with the rate of divorce rising at first as relative income increases, then hitting a maximum, and then decreasing with additional relative income. This is in conformity with the theoretical model of the "new home economics," where increased income represents both a source of freedom to make adjustments and a means of compensating for marital discontent. The presence of marriage-specific capital in the form of young children tends to decrease the divorce rate, while female participation in the labour force (which may represent an enlargement of

the opportunity set for females or simply a source of freedom from an unsatisfactory marriage) is positively associated with the rate of divorce. The R^2 of this equation is 0.99.

Turning to the fertility rate equations, the results are quite interesting and generally (but not always) in conformity with theoretical expectations. The demographic determinants are not unimportant: thus for the 20-24 and 25-34 year-old women, the proportion of births is strongly influenced by the proportion of this female population that is already married. An increase in the lagged divorce rate for two of the age groups is negatively associated with the fertility rate, while for the two youngest age groups an increase in the lagged marriage rate is associated with an increase in the fertility rate. However, for the 25 through 34 year olds, an increase in the marriage rate has the opposite effect (for a given value of the stock of married women) and is associated with a decrease in the fertility rate. This suggests that these slightly older couples may postpone child-rearing (and hence child-bearing) until they may have accumulated the consumer capital that they deem necessary to the task. For all four age groups, relative income is negatively and significantly associated with the fertility rate, but this may reflect no more than a declining trend over the sample period (1960-1984). Alternatively, the negative coefficient on relative income could reflect a tendency for couples to substitute "high quality" children for numbers of children, as Leibenstein once argued. There is some evidence (for the oldest and the youngest age groups) that the fertility rate is reduced by labour force participation on the part of women, while for the youngest age group lagged school enrolments are also negatively (and significantly) associated with the fertility rate. Interestingly, the fits are rather tight for this relationship, although there is some sign of autocorrelated disturbances for the two oldest age groups. Howland takes the view that births outside this age range (15 through 44 years of age) are largely random events and cannot be modelled successfully by means of a regression equation.

Howland fitted marriage-rate equations for females aged 15-19, 20-24, 25-34, 35-44, 45-54, 55-64, and 65 and over – seven groups in all. One of the interesting demographic determinants is what Howland calls a "marital squeeze" variable; namely, the ratio of males to females in the relevant age group. In view of the fact that males tend to be the scarce factor after childhood, Howland postulates that increases in this ratio should be associated with increases in the marriage rate. This is generally the case, although the fitted regression coefficients are not always statistically significant. The various rates of marriage are positively associated with relative income, while the marriage rate is generally negatively and significantly associated with the female income variable. This latter result is somewhat surprising and Howland explains it by arguing that a high female income represents "a decrease in the benefits of specialization within the marriage." Along these lines, there is some tendency for labour force participation to be a substitute for marriage for females aged 45 through 54 and 55 through 64, although for the 65 and over group the relation switches to one of complementarity. The unemployment rate was hypothesized to display a negative relationship with the marriage rate, but this effect shows up for only the youngest age group (15 through 19 years of age); for the older age groups the relationship is positive when it is statistically signficant, suggesting that marriage may substitute for gainful employment, as conventionally measured. Finally, marriage rates show a discrete decline after 1968, which Howland associates with the changed divorce legislation but which equally might be associated with changed social attitudes toward less formal arrangements for living.

For five of the seven groups, the fits are relatively tight, with coefficients of determination equal to 0.9 or greater; however, for the two important age groups 20 through 24 and 25 through 34, the fits are much lower, suggesting the possible importance of non-economic factors in explaining all of these time series. The Durbin-Watson test statistics suggest the presence of mildly autocorrelated disturbances, for the five youngest cohorts.

Howland also fits two university enrolment equations (one for total female undergraduate enrolments and one for total female graduate enrolments) that display very tight fits (R^2 over 0.99), although there is some evidence of serially correlated disturbances. The expectation is that a rise in the ratio of white-collar to blue-collar salaries will stimulate enrolments and this expectation is confirmed in both cases (although only with a distributed lag in the case of graduate studies). Howland also expects that a rise in the ratio of white-collar to blue-collar employment will encourage young women to continue their education (as this represents a relative expansion of the opportunities for university graduates in general, and female university graduates in particular); in both cases, this expectation is confirmed. On the other hand, the unemployment rate has a negative (but only marginally statistically significant) coefficient for female undergraduate enrolments that is contrary to expectations, as Howland hypothesizes that high unemployment will encourage further study (as the individual may sense the need to upgrade her qualifications in a tight job market and also because the current opportunity cost of further training is lower). It is possible, however, that high unemployment deprives families of the opportunities to finance the university studies of youth in general and young females in particular. Interestingly, the unemployment rate (both current and lagged) has the expected positive effect on female graduate enrolments. Howland also theorizes that female enrolments should be positively related to labour force participation rates for females 15 through 24, as women realize that competition for desirable positions will intensify as they (as a group) move away from their traditional roles as wives and mothers. This expectation is borne out for graduate enrolments, where the lagged participation rate has a regression coefficient that is both positive and highly significant statistically. For female undergraduate enrolments the corresponding coefficient is still positive, but not statistically significant. Finally, we note that, in her projection exercises (which are partial rather than based on the full model), Howland projects that the upward trend in female undergraduate enrolments will continue for the next 20 years, after a fairly sharp cyclical interruption; in the year 2005, female undergraduate enrolments are expected to be roughly 20 per cent greater than in 1985. By contrast, female graduate enrolments are expected to be virtually trendless over the next 20 years, a conclusion that must be worrisome to those who would wish to see a greater sharing among men and women of positions of high responsibility and power.

As indicated above, Howland redoes the TIM labour force participation rate equations for 13 "secondary" groups, splitting off the 65 through 69 year-olds from the remaining seniors. Her detailed findings will not be summarized here, due to lack of space; however, she does give slightly more emphasis to demographic factors than do the standard TIM formulations. Interestingly, it appears that the data have enough independent variation to allow only one principally demographic influence to shine through for each female cohort. (Howland mentions that multicollinearity was, indeed, a problem for this set of regressions.) Thus, for young females 15 through 19, high school

enrolment rates reduce labour force participation; for young women 20 through 24, fertility impedes labour force participation; while for women 25 through 34 and again 35 through 44, a high stock of university graduates is positively and significantly associated with labour force activity. (For this latter group, a high divorce rate is positively and signficantly associated with labour force participation, which makes good economic sense in that standards of living often fall after divorce.) For the female group aged 45 through 54, there is no specifically demographic variable influencing labour force activity, and this is also true for senior women (aged 70 and above). For the groups aged 55 through 64 and again 65 through 69, labour force participation is positively and significantly related to the ratio of employment in "women's" occupations to total employment; this latter group shows labour force activity related negatively (in a statistically significant manner) and perversely to the divorce rate. For the males, the results are much more standard; for young males, participation rates are negatively related to school enrolment rates, while for older males labour force activity appears to fall off if other income sources (formal retirement, Workmen's Compensation) are available.

We have already referred, in passing, to Howland's projections of her demographic subsector to the year 2005. While these results are not of central interest (and are not generated by the full econometric model in any case), we may note the following results that seem to be different from other sociodemographic projections. Howland foresees a decline in the participation rates of young women and of women over 65 years of age. Also on the horizon appears to be a mini baby-boom for women aged 25 to 34. As well, the institution of marriage may be making a vigorous comeback, as judged by increasing marriage rates. Of course, these "forecasts" remain highly speculative, if intriguing, at this point.

e. Uses of the TIM Model, Past, Present, and Future

Like any general-purpose model, TIM is a very flexible instrument and can be used for a variety of simulations. TIM's basic use has been to serve as a framework for the medium-term projections or "scenarios" of Informetrica's National Forecast Service. In this service, one projection alone is never given; rather, the Informetrica people attempt to provide an informal confidence or tolerance interval by indicating the variety of developments possible, based on the evolution of the exogenous variables.

Three general uses of TIM may be summarized very rapidly. In 1982 and again in 1984, TIM has been used in seminars studying the properties of leading Canadian macroeconometric models in general and their behaviour in counter-factual simulations in particular; these seminars were sponsored by the Department of Finance.[23] This scholarly use contrasts with the practical use that the Informetrica personnel make of TIM in their Provincial Forecast Service, which is based on a "top-down" *R*egional *I*nformetrica *M*odel (RIM) and hence is quite dependent on TIM. TIM has been used for a number of special studies, such as one carried out to measure the likely macroeconomic effects of the introduction of severe anti-pollution regulations around 1980. (A similar study in the U.S.A. was also carried out by Data Resources, Inc. (DRI) and by Michael K. Evans of Evans Econometrics around that time, when this subject was fashionable.)

Of greater interest to us in this study is the detailed study that Carl A. Sonnen and M.L. McLaren of Informetrica Limited carried out for the Department of Employment and Immigration in June 1978. This study, entitled "Macroeconomic Effects of Immigration," parallels the Davies studies (1974, 1977) and that of Rao and Kapsalis (1982); it takes a large-scale macroeconometric model and seeks to answer questions concerning likely future macroeconomic impacts of varying immigration policy. These studies are reviewed in the following section.

6. Some Recent Applications of the Models Measuring Macroeconomic Impacts of Immigration

The primary purpose of the major applications of the Canadian models with respect to the role of demographic variables has been to assess the impact of immigration on the Canadian economy. Davies (1977) tested the short- and medium-term effects of varying levels of immigration and compared the simulated results derived from CANDIDE, TRACE and RDX2. His main objective was to determine whether the three models gave similar results when simulated with a standard set of demographic variables over the same time horizon.[24] Assuming a fixed level of emigration at 60,000,[25] Davies generated three scenarios from each model over the time period 1961-1974 corresponding to three different levels of net immigration: 0, 100,000 and 200,000 per annum. All three models predicted the effects almost always in the same directions but with somewhat different magnitudes.

Specifically, it was observed that an increased level of immigration raised the value of real GNE and the employment level, marginally lowered real output per capita, raised the level of the unemployment rate and reduced the rate of inflation. Furthermore, aggregate real expenditure on consumption and residential investment went up in all models; however, the expenditures on business investment went up only in CANDIDE and RDX2 but not in TRACE.

In spite of the strong similarities in results obtained for all three models, their cautious interpretation was suggested by the author and several caveats were noted. Moreover, the possibility of mitigating adverse effects by the government's expansionary fiscal and monetary policies was also recognized. In particular, it may be pointed out that the three models simulated had no structural mechanism to distinguish the behavioural characteristics of the new immigrants vis-à-vis the prior residents. For example, on the demand side, it was implicitly assumed that additional immigrants have the same consumption propensities as typical residents. More realistically, it may be noted that the consumption propensities of immigrants may be lower in later years as they remit funds to relatives and dependents left behind. Similarly, on the supply side, it was assumed that new immigrants have the same characteristics as the labour force that is already resident. In fact the age/sex composition of immigrants and their cultural characteristics affecting their propensity to seek employment (and, hence, their participation rates) may cause significant changes in the labour force. Furthermore, none of the models recognized the impact of inflows of capital funds brought in by the immigrants, the effects on the distribution of income of prior residents and the geographical distribution of the overall economic effects. And finally, all economic effects were measured by assuming no special

fiscal or monetary policy response on the part of the government to the increased level of immigration. This was at least one shortcoming that was dealt with directly in a similar study undertaken by Informetrica.

Sonnen and McLaren (1978) studied the macroeconomic effects of immigration to Canada by simulating the Informetrica Limited National Forecast Service annual model (TIM) for the period 1978-1985. Altogether six scenarios were generated; the first served as a reference case. In the reference case, net immigration in both 1978 and 1979 was assumed to be 25,000 and thereafter this number was raised annually by 10,000 to a level of 85,000 in 1985. The next three scenarios were generated by assuming levels of net immigration different from the reference case by minus 50,000, plus 50,000 and plus 100,000 in each of the eight years simulated. These levels were chosen in equal increments (or decrements) to determine whether the economic effects of immigration were proportionately symmetrical with respect to its movements in upward or downward directions, and whether they were linear with respect to its size. Equally important were the remaining two scenarios that once again corresponded to the minus 50,000 and plus 100,000 cases defined above, but which now included a special assumption about the policy response of the government with regard to aggregate demand. It was assumed that the government would adjust its fiscal and monetary policies in order to keep the unemployment rates in line with the reference case. These two were called the compensated cases.

There were two mechanisms through which alternative assumptions about future immigration were made to influence the calculations: (a) the population module, and (b) the set of exogenous variables. In the population module (submodel) of TIM, the new immigrants entered population directly and were distributed to age-sex groups in average proportions experienced during the 1950s and 1960s . Furthermore, the birth and survival rates of these immigrants were assumed to be the same as those for the entire population. The effects of immigration on the economy through population changes appear directly at several places on both the demand and supply side of TIM. However, to capture their indirect (or additional) effects, several exogenous variables were also adjusted. These exogenous variables were deemed to be related directly to the number of immigrants and the subsequent demographic changes, or indirectly to those economic factors, such as the size of real GNP and the level of prices, that the number of immigrants are most likely to affect. Forty-two such exogenous variables of TIM were adjusted in total. As a matter of procedure, the population submodel was run first independently for each level of net immigration, and the effects on related demographic variables such as growth of population, households and the labour force were estimated. Approximately 20 of the adjusted exogenous variables were further affected by such demographic linkages. Thus, the whole simulation procedure imparted a greater degree of 'realism' and 'accuracy' to the calculations.

The overall results were in line with other studies. They suggested "that increases in immigration lead to a larger economy, probably some slight increases in the unemployment rate, negligible effects on prices, and some likely deterioration in government and current account balances".[26] (Sonnen and McLaren 1979, Executive Summary) Furthermore, it was also evident "that the unfavourable effects are small; that governments could act to offset wholly or partially many of these unfavourable

effects; and that the administration of immigration may itself lead to quite different results". (Sonnen and McLaren 1979, Executive Summary)

The size of the economy, whether measured by total expenditure, output or income, was seen to vary proportionately with the size of net immigration. Although, as expected, four-fifths of the change in GNP was absorbed by consumer expenditure, the most lasting effects on the composition of demand were concentrated on investment categories (e.g., service, manufacturing and construction industry). Similarly, although immigration did not significantly affect the general inflation, it did have some localized impacts on prices and wage rates. The unfavourable effect on the unemployment rate was weaker than what has been found in other studies. Moreover, the compensated simulations indicated that government could stimulate the economy to offset the increase in the unemployment rate without causing major distorting effects elsewhere. The study concluded "that reasonable, alternative levels of immigration are not likely to cause major instabilities to the Canadian economy or to lead to the forfeitures of major opportunities. The choice of whether more or fewer persons are permitted to immigrate must rest on grounds other than those of macroeconomic effects". (Sonnen and McLaren 1979, p. 58)

Rao and Kapsalis (1982) investigated "the effect of an additional 50,000 immigrants a year until the end of this decade" by simulating the CANDIDE (version 2.0) model. They were motivated to check the desirability of the recommendation contained in the report of Employment and Immigration Canada (1981). This report had recommended selective immigration of skilled workers to meet labour shortages, particularly "to meet unanticipated and peak skill requirements for which it is not possible to train domestically". (Employment and Immigration Canada 1981, p. 205) Their shocked solution of the CANDIDE model was obtained by increasing net immigration from 50,000 to 100,000. They also used the key assumption that with the exception of age/sex differences, the additional immigrants would have job characteristics similar to those of the general population.

The simulation results of this experiment indicated that a net addition to immigration by 50,000 a year would lead by 1990 to an increase above the base solution by 2.53 per cent in total population, 6.60 per cent in number of births, and 5.56 per cent in residential construction. There was also an evidence of a slight decline in both the wage rate and the inflation rate. But two of the most undesirable effects noted were an increase in the unemployment rate and a decline in the real per capita GNP. (By 1990, the unemployment rate would be 0.7 of a percentage point above the base solution and per capita GNP would fall below by $231 (in 1980 dollars).) In fact, contrary to the results of the Informetrica study, they found this cost in terms of a decline in per capita income "staggering", and came to the conclusion, "In view of the cost, a case could be made for more extensive reliance on domestic sources – through training and relocation programs, and policies to encourage female labour participation – which may be less costly than increasing immigration." (Rao and Kapsalis 1982, p. 382)

Rao and Kapsalis did provide a caveat to their conclusion by acknowledging that their "simulation has overestimated the cost involved. For example, it was not taken into account that immigrants often bring with them financial capital or that their human capital has been financed mostly by the taxpayers of the countries of origin." (Rao and

Kapsalis 1982, p. 379). Robertson and Roy (1982) brought out some further limitations of the analyses of Rao and Kapsalis, which will be discussed in the final section.

7. Concluding Remarks and Recommendations

How seriously should these simulation studies (of the effects of increased immigration on the Canadian economy) be taken? Matthew Robertson and Arun S. Roy (1982), in a hard-hitting critique, argue that the limitations of the macroeconometric models, such as CANDIDE 2.0 and TIM, are such that these results should not be taken seriously at all. They point to various defects (some of which we have already noted in Section 6 above), such as the fact that immigrants' differences from the population already resident in Canada may not be sufficiently taken into account. Thus immigrants may have different propensities to consume (in total or on individual categories of consumption expenditures); they may have different labour force participation rates; their age composition and other relevant demographic characteristics (e.g. fertility rates) may be different. None of these effects are captured by the macroeconometric models. Moreover, the occupational skills of immigrants may be higher than those of the already resident population, given the stringent criteria to which ordinary (i.e., non-family and non-refugee) immigrants are subject, yet the models do not capture these effects, as the skill composition of the labour force is not a relevant endogenous variable of CANDIDE or TIM. Moreover, immigrants may bring with them substantial capital funds, yet the influence of these capital imports on consumption, residential construction and business fixed investment is not sufficiently taken into account in the models. Thus, it is fair to say that the model simulations are less than fully complete in their estimation of the effects of increased immigration on the Canadian economy.

Moreover, there are some theoretical factors that are well worth pointing up, also. As Marr and Percy (1984) indicate in their study for the Macdonald Commission, to assert that real per capita income might fall slightly due to diminishing returns on the natural resource base of the Canadian economy is not to assert that the real income of Canadians already resident in the country before the new increased levels of immigration will fall, because the new immigrants may work for less than established residents, or because the return to the capital owned by the existing residents may rise. (In turn, the new immigrants may earn more than they would have earned in their countries of origin, so it is indeed possible for immigration to represent a set of circumstances where everyone wins. This could even be true for the sending areas, if increased immigration alleviates pressures on limited resources and capital there.) In addition, there is another consideration to take into account. Denton and Spencer (1984) have indicated that the relative burden of government expenditures on health expenditures and on social transfers to the aged (principally pensions) is likely to increase markedly in the next 45 years. Certainly, a policy of high population growth through immigration is one manner of counteracting such trends, thus keeping the burden of direct and indirect taxation within meaningful bounds.[27] While this effect could, in principle, be captured by the model simulations, in practice such an effect is likely to appear only in the very long run (after 20 years or later), which is beyond the horizon of the models that have been employed for these sorts of simulations.

We may conclude this part of our discussion by observing that Sonnen and McLaren (1978) have been careful not to claim too much for their medium-term simulations. Thus they recognize that there are a number of effects that have not been captured, and so it must be recognized that the results obtained are not exceedingly precise. They seem, however, to give results that are accurate enough to assert that disaster does not loom if the levels of net immigration are increased within the realm of historical experience. Moreover, the CANDIDE, TIM, and RDX2 results should probably be interpreted as "lower bound" results, as the compensated TIM solutions bring out clearly. In our view, these simulations are quite useful as "ballpark figures", and the fact that their application to concrete problems of policy must be tempered with other evidence and (especially) with good judgment does not vitiate their usefulness.

We may conclude this survey with several more general observations.

First, we observe that a fully satisfactory socioeconomic model, with full links between the demographic mechanisms of society and the macroeconomy proper, does not exist at present. Nevertheless, a number of interesting links have been built in partial studies, and it is our judgment that the technology exists presently to build a satisfactory macroeconometric-demographic model that would be useful for socioeconomic projections at least 12 years into the future (and, with somewhat less rigour, perhaps even 20 years into the future). While the measurement problems should not be underestimated, we feel that enough can be done to make this a useful as well as interesting exercise. At critical points, survey information could be brought into the picture (e.g., the different composition of immigrants' consumption expenditures, as well as their tendencies to invest in residential construction and business fixed capital formation). These added bits of pertinent information could then be used to adjust the macroeconometric models, when doing long-term macroeconometric-demographic simulations.

Second, a very important question that has been raised concerns the capacity of the macroeconometric models to deal satisfactorily with changes in the structural parameters that may occur when relationships are estimated for long periods of time. In general, no fully complete answer can be given to this question, but it is one that deserves careful consideration, since the estimation theory with which we work assumes an unchanged underlying structure. However, some tricks can be used (judicious employment of time trends, dummy variables, discarding of abnormal periods such as war years, etc.) in order to make the appropriate sample period as long as possible. Nevertheless, it is our feeling that the scenarios of macroeconometric models such as CANDIDE and TIM lose reliability the further one projects into the future, precisely because the assumption of unchanged economic and demographic structure becomes less and less tenable. Our own preference is for projections that run only five to 12 years into the future, which we regard as a true "medium-term"; however, for some purposes, it might be worth while to make projections even 20 years into the future, all the while recognizing that such scenarios are (at best) indicative. (On the other hand, alternative methods of crystal-ball gazing are also very much subject to error and to revision, precisely because (in our view) the long-term future is not a fully determined phenomenon.)

Third, we note that good progress has been made in explaining participation rates in recent years, and this aspect of the macroeconometric model-building exercise is

steadily improving, as a greater number of relevant determinants (including the strictly demographic influences) of participation in the economically active population have been identified and estimated. Nevertheless, it must be admitted that prediction of this aspect of the macroeconomy was a humbling experience during the 1970s, as model-builders generally missed a good portion of the increase in the female labour force. The work of Howland (1986) holds, in our view, considerable promise precisely because such demographic influences are more fully taken into account. However, with new research nothing is guaranteed, and these results could conceivably not be equal to the task of longer-term socioeconomic simulations. Nevertheless, we remain hopeful.

In this connection, it may be observed that, at this point, relative (or absolute) changes in the participation rates of age-sex cohorts are not modelled to affect the wage incomes of these specific groups, as wage determination does not function that way in the macroeconometric models. Instead, the wage rate is determined more globally in a major sector of the economy as a whole, or else it is determined in major industries (such as manufacturing, construction, agriculture, etc.) of the economy. Moreover, even though we can think of various reasons why variations in labour force participation rates could be associated with changes in the composition of demand[25] (either final demand or the demand for various occupational groups), such effects are not present in any of the major macroeconometric models, to the best of our knowledge. Accordingly, the models do not generate information on occupational wage rates or occupational wage structure, and thus the fascinating question of labour market segmentation (and its evolution over time, say in the context of slack labour markets or increased or decreased levels of immigration) cannot be approached in the context of the macroeconometric models.

Fourth, we may note that propensities to consume (or household propensities to save) are partially responsive to demographic influences, in a modest way. As noted in preceding sections, CANDIDE Model 1.1 incorporated an age-dependency variable in explaining personal discretionary savings, and a modest effect of demographic forces (an explanation of private contractual saving on a per-employee basis) appears in TIM. More could doubtlessly be done in this regard (e.g., recognition of the temporarily high dissaving of the typical household in connection with engagements, marriage, and divorce), but at least a beginning has been made, in this regard.

Another fascinating subject, much discussed in the popular press currently, is the informal/underground economy. With regard to the informal/underground economy, we know of no way to model its various phenomena econometrically, because estimates of illegal activities (and/or those not transacted against money) are notoriously difficult to obtain. For instance, it is difficult enough to obtain estimates of gross immigration and emigration separately; the break-down of total gross immigration into legal and illegal components is almost an impossibility as a problem of applied statistical measurement.

Finally, turning to questions of immigration proper, we note that there are a number of difficult questions that will have to be answered approximately, if at all, for some years into the future. Thus, since even the numbers of emigrants is subject to some question, their socioeconomic characteristics (e.g., age distribution, capital funds exported with themselves, consumption propensities, tendencies to participate in the labour force, etc.) will have to remain open questions. (The effects on Canadian production and real

product per capita will differ greatly, depending upon whether the typical departing migrant is an old-age pensioner or a world-famous NRC scientist.) A special study could be mounted, but it would probably be frightfully expensive. Even for immigrants, we have very little hard knowledge with regard to how these individuals differ from the already-resident population, with regard to all of these critical socioeconomic characteristics. As fragmentary evidence comes in, it can of course be incorporated into the projection exercises,[29] but it is our guess that the best that we shall be able to do for many years to come is to adjust constant terms of certain pertinent relationships, rather than adjust the slope paramenters of various key explanatory variables. As an example, it must be admitted that the effects of specific immigration flows to mitigate particular bottlenecks (e.g., the importation of rare engineering skills in the natural resource industries, for instance) have been, are, and will continue to be (into the indefinite future) very hard to capture with the macroeconometric models. (This example also illustrates the limitations of macroeconomic modelling as a technique for studying labour market segmentation, as we have already discussed above.) Such specific disaggregative effects will remain a qualification on the results of the macroeconometric models (even when augmented by a quite sophisticated demographic sector), and there would appear to be little that purely macroeconomic analysis, in the context of the models, can do to overcome this limitation.[30]

In terms of further research, then, we feel that such good beginnings should serve as the foundation for additional study. A population submodule of a disaggregated macroeconometric model could be further tested and researched, particularly in the context of full model simulations. We may be on the threshold of a pronounced step forward. In any case, owing to both the importance of the questions and the interest of the subject, we owe it to ourselves to try.

Footnotes

1. See M.C. McCracken, "Demographics and Corporate Investment Decisions", mimeographed paper presented to the Conference on Socio-Demographic Change in Canada: Its Impact on Business and Public Policy, June 24-25, 1981, where the author argues that even a large proportion of business fixed investment will be sensitive to demographic factors.

2. For the historical background of the Canadian macroeconometric modelling, we refer to our recent paper (R.G. Bodkin, L.R. Klein and K. Marwah 1985).

3. In fact, Brown titled it "A Sectoral Model of the Canadian Economy", (1970, p. 380). The purpose of the partitioning into industrial groups was "to recognize the distinctly different technologies and market characteristics of agriculture and non-agriculture", in accordance with aggregation principles.

4. The absence of any policy instruments precluded any possibility of standard policy simulations.

5. This model is included in our discussion because it is interesting to note what is omitted from a leading Canadian macroeconometric model of the era, in spite of the fact that it clearly recognized the open character of the Canadian economy. However, it might be noted that demographic phenomena may be less important (say, in comparison with the previous model surveyed) in a short-term context.

6. See Carr, Jump and Sawyer (1976).

7. RDX1, the predecessor of RDX2, is not reviewed explicitly here due to constraints of time and space.

8. In part, this tendency of short-run productivity ratios to vary with the state of utilization of the productive facilities was built into the specification. In any case, it is interesting to note that there is a hierarchy of speeds of response of the factor inputs; first, average weekly hours adjust, then the number of employees, and finally, the amount of capital stock employed in this production sector.

9. This variable is exogenous, so that family formation was not a process explained in RDX2.

10. To be fair, we should note that the authors of RDXF also intended it to be a useful source of alternative scenarios over a medium-term horizon, even given the fact that it is a quarterly model.

11. In the December 1983 version, as Grady (1985) points out, this equation has been further refined to allow for a distinction between the long run and the cyclical sensitivity of the participation rate of labour demand pressures. Although in both cases higher labour demand expands the labour force (the "discouraged worker" phenomenon), in the long run the expansion of the labour force due to greater employment opportunities is almost twice as great.

12. Models 1.0 and 1.1 had equations for determining the rate of foreign exchange in a floating rate system, but their performance was bad enough that, in practice, this variable was treated as an exogenous policy instrument.

13. If the focus had been short-term forecasting, a quarterly model almost certainly would have been used. In any case, longer-term considerations (such as capturing medium-term sales-stocks ratios in inventory investment equations) were more important than in the typical short-term model.

14. Strictly speaking, this is not true for all of the terms in the distributed lag for U.S. unemployment rates and also for the Expo 67 dummy in the Model 1.1 equation.

15. These equations show the birth rates falling with rising per capita income, but this undoubtedly reflects common trends over the sample period.

16. This equation shows marriage rates depending negatively on the lagged unemployment rate and positively on its own lagged value, as well as insignificantly on the lagged divorce rate.

17. In particular, this variable was measured as the ratio of young people aged 0 to 19 to the male labour force 25 through 54 years of age.

18. Grady Associates (1985) assert that the March 1984 version of TIM had 3,914 total equations, of which 1,206 were behavioural, with 998 exogenous variables, but our suspicion is that this count may be somewhat inaccurate.

19. By way of reference, CANDIDE Model 1.1 had 2,049 equations, of which 616 were behavioural equations. There were only 450 exogenous variables (roughly).

20. In some other macroeconometric models, a "natural rate of unemployment" is defined, and this natural rate, which might well reflect demographic effects directly, would have some influence on the actual or current rate of unemployment. Here the unemployment rate is influenced less directly by demographic factors.

21. McCracken (1981) argues that even business fixed investment outlays are linked rather closely to the evolution of the underlying population basis of an economy.

22. It is well known that single equation criteria do not always indicate unambiguously how well (or how poorly) a new equation or group of equations will perform, in the context of the full model.

23. In a sense, the important review of the structure of various Canadian macroeconometric models produced by Grady Associates (1985) was an important by-product of the second Department of Finance conference, held in November 1984. The first conference, held in July 1982, was focussed more specifically on the comparative simulation properties of the various Canadian macroeconometric models; a report of some of the details of these comparison appears in O'Reilly *et al.* (1983).

24. An earlier version of TRACE modified by the author for another study (Davies 1972) was used for the analysis. This version included a demographic sector which explained the population and school enrolment by both age and sex.

25. The level of emigration assumed was the same as used in the Green Paper (Minister of Manpower and Immigration 1975:7).

26. Real income per capita fell under increased net immigration with the uncompensated simulations, but actually rose if the compensatory measures were adopted.

27. Conceivably, considerations such as these may have been behind the government's recent decision to increase slightly the immigration quotas for the coming year.

28. Thus, one might expect an increased female participation in the labour force to be associated with a decrease in food bought in the supermarkets and prepared at home and with an increase in restaurant meals; this effect, if present, is not found in TIM, for instance.

29. For instance, we note that in TIM the consumption category relationship for gifts in kind depends upon the ratio of total immigration to the entire Canadian population. The inclusion of this explanatory variable can surely be regarded as the incorporation of additional, fragmentary evidence.

30. In this connection, we are reminded of the qualification to macroeconomic theory that Charles L. Schultze's "demand-shift" inflation theory made a quarter of a century ago. Whatever the merits or demerits of this approach, Schultze's theory clearly implied that a purely macroeconomic analysis of inflation had its limitations, and that one could not satisfactorily analyze inflationary movements of the price level without studying particular sectors of the economy in which excess demand (due to a shift in the composition of demand) was present.

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